Quantum Materials
The Science

SAND2016-11801C

BES basic research needs workshop

- quantum fluctuations, quantum entanglement, quantum coherence, and topology of wave functions

Priority research directions for BES

1. Control and exploit fluctuations in quantum matter
2. Harness topological states for groundbreaking surface properties
3. Drive and manipulate quantum effect (coherence, entanglement) in nanostructures for transformative technology
4. Create revolutionary tools to accelerate materials discovery and technical deployment

Quantum Materials Science

A lot of well studied systems with new twists ...

- Spintronics, magnetic/multiferroic/ferroelectric systems
- Superconductivity
- Transport and non-equilibrium dynamics
- Topological materials
- Heterogenous and nanostructured quantum materials

Synthesis
- synthesis by design

New instrumentation and tools

Theory and modeling
- predicting behavior of materials
- approaches beyond one-electron

Materials by design

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Quantum materials integration at the user workshop

Plenary speaker – Dmitri Basov, *Quantum materials: insights from infrared nano-optics*

Optical and electronic techniques to control coherent systems

- semiconductor low dimensional systems
- topological materials
- 2D materials and monolayer semiconductors

Single spin physics

User panel

Quantum Materials

Competitive landscape, user engagement, program opportunities

- **Who are the leading groups for this area/capability? (US and overseas)**
  - Very wide range of groups already participating in this broad research area
  - on-going work is being defined as Quantum Materials
  - New highlighted efforts at a lot of universities
- **In the US: are there other NSRCs/university centers doing something similar? Do we have intelligence of similar plans?**
  - Harvard: Center for Integrated Quantum Materials (NSF center, $16M)
    - van der Waals heterostructures, topoloigical superconductors
  - NSRCs are connecting to Quantum Materials topics (CNM: Quantum and Energy Materials)
- **Are there examples of high profile publications generated by a similar effort or capability?**

yes

- **What type of user interaction will this require? (examples: “send samples”, onsite work, etc).**

CINT is already working in quantum materials

1. Non-equilibrium phenomena and transport
2. van der Waals films
3. nanotubes
4. optical and electronic measurement of coherent phenomena
5. multi-ferroics
6. colloidal quantum dots
7. ...

Estimate number of groups/user projects that this could generate

Existing CINT activities
van der Walls materials:
quantum design:
coherent spin systems:
single spin

Quantum Materials

Competitive landscape, user engagement, program opportunities

Program opportunities:

1. BES – Basic research needs workshop on quantum materials
2. Moore foundation (emergent phenomena in quantum systems)
3. DOE ASCR qubit testbed

Quantum Materials Integration
What would it take

If we want something separate (like a thrust), we need to focus on a part of this community:

1. Materials by design
   - modeling, synthesis, measurement/characterization

2. Quantum measurements
   - new approaches for measuring quantum phenomena
   - vision: new generation of user tools for the Quantum Materials community

- **Why CINT? Do we leverage the labs, and/or CINT existing staff/capabilities?**
- **Staffing: would this rely on existing CINT scientists? New hires (how many)?**
- **Equipment: assess cost**
- **Building requirements: new space?**
- **Provide time to generate first results**
- **Could this connect or generate a new discovery platform?**